Operational Risk Management is Ineffective at Addressing Nonlinear Problems

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A good indication of how much damage will result from a fire is the number of firemen fighting it. The more firemen fighting a fire, the more damage occurs. Therefore, in order to reduce the resulting damage, fewer firemen should be used to fight fires. This example illustrates how the wrong conclusion can be arrived at by taking a complex, nonlinear problem and oversimplifying it to fit a linear solution. Plotting the number of firemen versus the degree of damage will yield a linear graph from which one can draw the conclusion that more firemen will result in more damage. In linear systems, each variable's assigned value is independent of any other variable in the system. Keeping the rest of the system constant, one can manipulate only one variable and the system will give perfectly predictable results as the value of the one variable moves along its entire range. A matrix is another way of representing every permutation of possible outcomes of a linear system. Because the Marine Corps risk management process, called operational risk management (ORM), is a linear solution system, it cannot be effectively used to address more complex, nonlinear problems.

ORM

ORM assesses risk on a standardized matrix by indexing an assigned value, or weight, for the probability of a hazard occurring with an assigned value for the hazard's damage

severity (Figure 1). The result is called the hazard’s risk assessment code (RAC). Hence, the lower the RAC, the lower the likelihood and potential severity of any mishap.

		Probability of Occurrence			
		Likely A	Probably B	May C	Unlikely D
SEVERITY	Cat I	1	1	2	3
	Cat II	1	2	3	4
	Cat III	2	3	4	5
	Cat IV	3	4	5	5

Figure 1[1]

Risk Assessment Code	
Number	**Corresponding Level of Risk**
1	Critical
2	Serious
3	Moderate
4	Minor
5	Negligible

Linear Systems

Background

In the study of complex systems, the term “linear system” comes from the visual representation of a system and its variables in a straight line (Figure 2). “If (a) happens then (b) will follow” is an example of a linear system. Michael Waldrop describes linear systems as characterized by

> the whole being precisely equal to the sum of its parts. Each component is free to do its own thing regardless of what’s happening elsewhere.... Sound is a linear system, which is why people can hear an oboe playing over its string accompaniment and recognize them both. The sound

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[1] Marine Corps Institute, *Operational Risk Management 1-0 (Washington DC: Headquarters Marine Corps, 2002), 38*

waves intermingle and yet retain their separate identities. Light is also a linear system, which is why one can still see the *Walk/Don't Walk* sign across the street even on a sunny day: the light rays bouncing from the sign to one's eyes are *not* smashed to the ground by sunlight streaming down from above. The various light rays operate independently, passing right through each other as if nothing were there. [2]

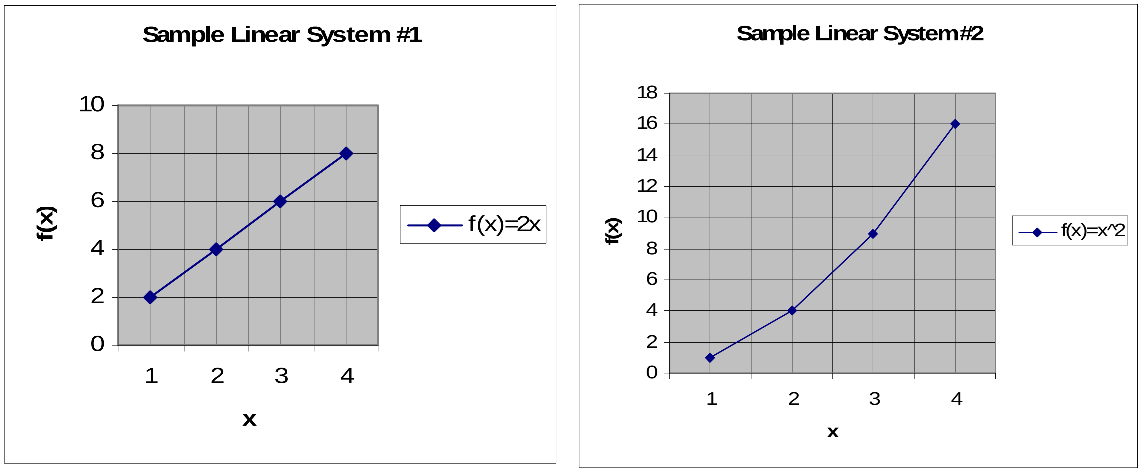

Figure 2

ORM Effectively Addresses Linear Problems

The ORM weighted matrix is useful when the commander can implement a control that directly (linearly) mitigates a starting variable's weight and, therefore, lowers the RAC. Neither the starting variable's weight nor the assumption made when assigning that weight matters. By unequivocally reducing the probability or severity of a hazard, the overall risk is reduced. Personal protective equipment (PPE) is a good example of this. PPE places a physical barrier between a hazard and an

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[2] M. Mitchell Waldrop, *Complexity: The Emerging Science at The Edge of Order and Chaos (New York: Touchstone, 1992), 64*

individual. For instance, bicycle helmets have unarguably been shown to reduce the severity of head injuries in bicycle accidents.[3] Because wearing a bicycle helmet directly and unarguably reduces the severity weight, a lower RAC will result -- no matter what other factors went into the assumptions when assigning the initial weight.

Nonlinear Systems

Background

By its very design, a linear system assumes its agents will act in a perfectly rational manner at all times. Waldrop explains:

> Perfectly rational agents... know everything that can be known about the choices they will face infinitely far into the future, and they use flawless reasoning to foresee all the possible implications of their actions. So you can safely say that they will always take *the* most advantageous action in any given situation, based on the available information.... The only problem, of course, is that real human beings are neither perfectly rational nor perfectly predictable.[4]

[3] Dr. Michael Henderson, "The Effectiveness of Bicycle Helmets: A Review," *Bicycle Helmet Safety Institute*. 1995, < http://www.helmets.org/henderso.htm> (16 December 2008).

[4] Waldrop, *Complexity, 143*

Nonlinear systems are more complex, harder to understand, and harder to predict. Visual representations of nonlinear systems do not look like a straight line.

> Our brains are not linear: even though the sound of an oboe and the sound of a string section may be independent when they enter your ear, the emotional impact of both sounds together may be very much greater than either one alone. (This is what keeps symphony orchestras in business.) Nor is the economy really linear. Millions of individual decisions to buy or not to buy can reinforce each other, creating a boom or a recession. And that economic climate can then feed back to shape the very buying decisions that produced it. Except for the very simplest physical systems, virtually everything and everybody in the world is caught up in a vast, nonlinear web of incentives and constraints and connections. The slightest change in one place causes tremors everywhere else.... The whole is almost always equal to a good deal more than the sum of its parts.[5]

ORM Ineffectively Addresses Nonlinear Problems

One of the downfalls of weighted matrices is that the user is forced to make huge assumptions about the values assigned to the x and y axis of the matrix. ORM fails when the starting assumptions are misunderstood or too hard to determine, such as when applied to problems involving people. “In nonlinear systems... chaos theory tells you that the slightest uncertainty in your knowledge of the initial conditions will often grow inexorably. After a while, your predictions are nonsense.”[4]

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[5] Waldrop, *Complexity, 65*

Example

A standard practice among Marine Corps commanders is to require their subordinate leaders to gain approval if the risk assessment of a mission results in a RAC above *moderate*. The reader will find that it is common practice for subordinate commanders to tweak the weights of either the hazard assessment or control effectiveness in order to produce the “proper” results. For instance, the subordinate commander may go back and lower the initial risk assessment of a mission or raise the effectiveness of training as an implemented control. Regardless of what the actual severity or probability of a hazard may be, or how effective a control may or may not actually be, one can be sure the final RAC will be *moderate* or below so approval from higher is not required. After all, those starting weights are only assumptions in the first place.

RAC codes above *moderate* are found only when a standard mission risk assessment checklist is used that explicitly states some definable factor, such as weather, automatically results in a RAC code above *moderate*. Rather than a proper risk assessment process, ORM becomes a (linear) GO-NOGO checklist. This checklist removes assumptive powers from the subordinate commanders. Instead, the creator of the checklist makes all the assumptions for them as if he knows everything that can be known about the choices the subordinate commanders will face

infinitely far into the future and as if he has used flawless reasoning to foresee all the possible implications of their actions.

Motorcycle fatalities are an unfortunate example of ORM ineffectiveness in the real world. Motorcycle risk control measures, from PPE to registration to safety course requirements, have seen drastic, some would say draconian, implementations in the last few years, all of which appear to address the problems of motorcycle fatalities. However, the latest figures show that Marine Corps motorcycle fatalities have steadily increased from 9 in 2004 to 25 in 2008.[6] More young Marines may be keeping their motorcycle riding a secret, so the required weeks of motorcycle classes does not impact their training progression, and so the cost of required equipment does not impact their pocketbooks. Perhaps the criminalization of regulations has given incentive to Marines to run from the police instead of stopping. (In how many other ways might the Marine Corps be sending fewer proverbial firemen in order to reduce damages?)

Because the knowledge to truly address a problem is lacking, and saying “no” is taboo, commanders are often forced

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[6] Dan Lamothe, “Top Service Leaders Meet With Industry on Bike Safety,” Marine Corps Times, January 26, 2009, 18.

to pay lip-service to safety by saying “yes” without actually doing anything substantive. In 2005, the Secretary of Defense mandated a 50% reduction in mishaps. Shortly thereafter, the Marine Corps changed the way damages are accounted for from “damage caused” to “cost to repair.” For example, crash the “right” vehicle (one that was scheduled to be overhauled anyway) and the ‘cost to repair’ is zero whereas “damage caused” would have been sizeable. This reduced the number of mishaps, as determined by monetary threshold, but did not make the Marine Corps any safer. A system for finding viable solutions to these more complex, nonlinear problems encountered by commanders is required.

Nonlinear Solutions

The study of nonlinear systems draws from across the scientific fields and has evolved a wide variety of models to help find solutions to nonlinear problems. One model used to represent nonlinear systems is “connectionism,” which is “the idea of representing a population of interacting agents as a network of ‘nodes’ linked by ‘connections.’”[7] Representing the Marine Corps population in a connectionist network model would require studying the relationships between the 202,000 Marines

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[7] Waldrop, *Complexity, 289*

and how they affect each other. It would require consultation with sociologists, psychologists, and anthropologists. The network agents could be described by the existing data within the comprehensive Marine Corps personnel databases detailing each Marine’s background, age, training, operational experience, personal status, etc. The agents could be organized into nodes based on commands such as the units, schools, and bases of the Marine Corps. One could then see “how position in that network was associated with accident incidence; individuals with similar positions in the network might be thought to have common training experiences or similar ways of doing their work, and it would therefore be interesting to see if this led to similar accident records.”[8] One could also “build a regression model to predict the incidence of accidents, hazards, etc. based on their correlation with the personnel database information.”[9]

Nonlinear Solution Systems are More Complex

Nonlinear solution systems are harder to conceptualize and accurately construct. They require consultations with outside experts and will often produce ever-improving results as the

[8] John Roberts, “Statistical Inferences of Complex Human Behavior Networks,” Jan 18,2009, personal email (Jan 18 2009)

[9] Aaron Clauset, “Statistical Inferences of Complex Human Behavior Networks,” Jan 08,2009, personal email (Jan 08,2009)

model is corrected, rather than one result at the end of a defined timeline. The PowerPoint-, goal-oriented military is unused to this kind of ambiguity. However, the environment within which the military finds itself operating is continuously becoming too complex for simple linear solution systems.

Conclusion

In the counterinsurgencies of Iraq and Afghanistan, using superior firepower to obliterate enemy fighting positions by sending a bomb is much less risky than sending riflemen to destroy the enemy fighters. After years of fighting, the military realized that the collateral damage of those bombs actually fed the insurgency creating more risk for all in the long term. The real reasons behind a hazard’s probability or severity are often too complex to understand with a linear system. Instead commanders make their best guesses given the information at hand as to how to reduce risks to their personnel. With enough time and money, one can try every possible solution until some that work are found. In the near future, however, the funds will be going away. Commanders will be even more persuaded to pay lip-service to safety in order to appease their higher-ups, regardless of whether the answers or funding required to address the problem correctly exists. Instead of commanders making their best guesses within the

constraint of appeasing their superiors, a true knowledge of where efforts and funds will make an effective difference and save lives is desired. The more complex, nonlinear problems, such as those involving people, cannot be understood with linear solution systems. These answers will only be revealed by using a nonlinear solution paradigm such as a connectionist model. The linear solution system of ORM is ineffective at addressing these nonlinear problems.

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